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(54) **PURGE MECHANISM IN LINK AGGREGATION GROUP MANAGEMENT**

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(52) **U.S. Cl.** **370/236**; 370/367; 370/387; 370/417; 370/536

(58) **Field of Classification Search** 370/394
See application file for complete search history.

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(57) **ABSTRACT**

To enable quick movement of communications among links in a link aggregation group, network element use a purge mechanism. A network element implementing the purge mechanism may disable distribution of additional frames to output queues associated with aggregated ports and potentially drop some or all frames from the output queues associated with aggregated ports. In conjunction with the dropping of frames, the network element may exchange one or more marker messages and marker responses with a remote network element. After receiving appropriate responses, the network element may restart distribution of frames to the affected ports.

23 Claims, 6 Drawing Sheets

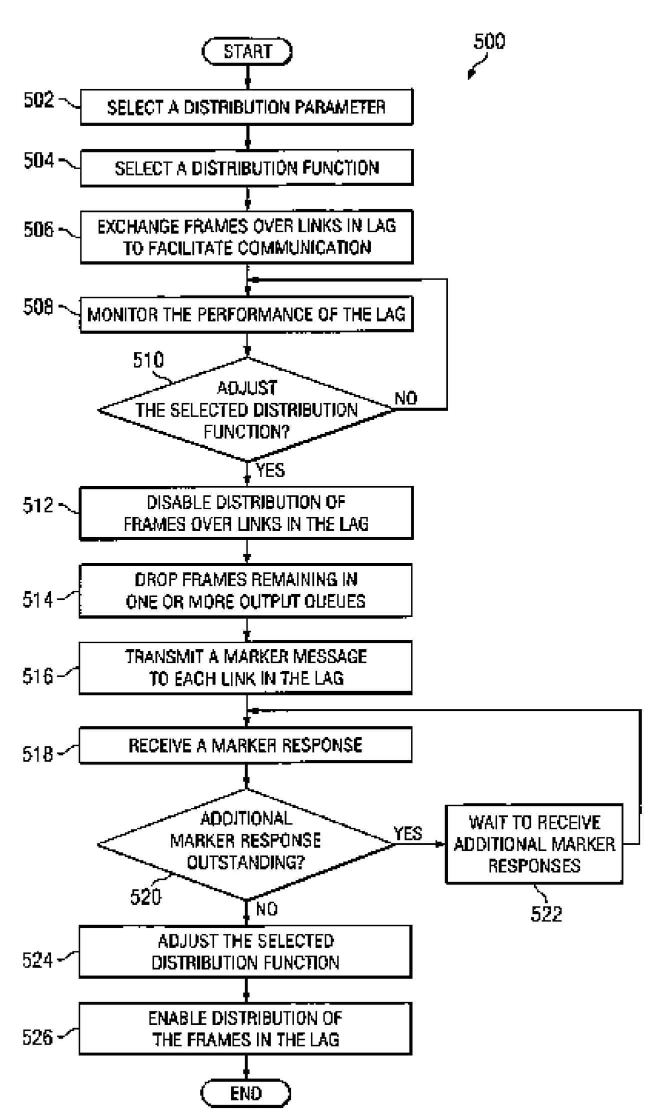

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FIG. 1

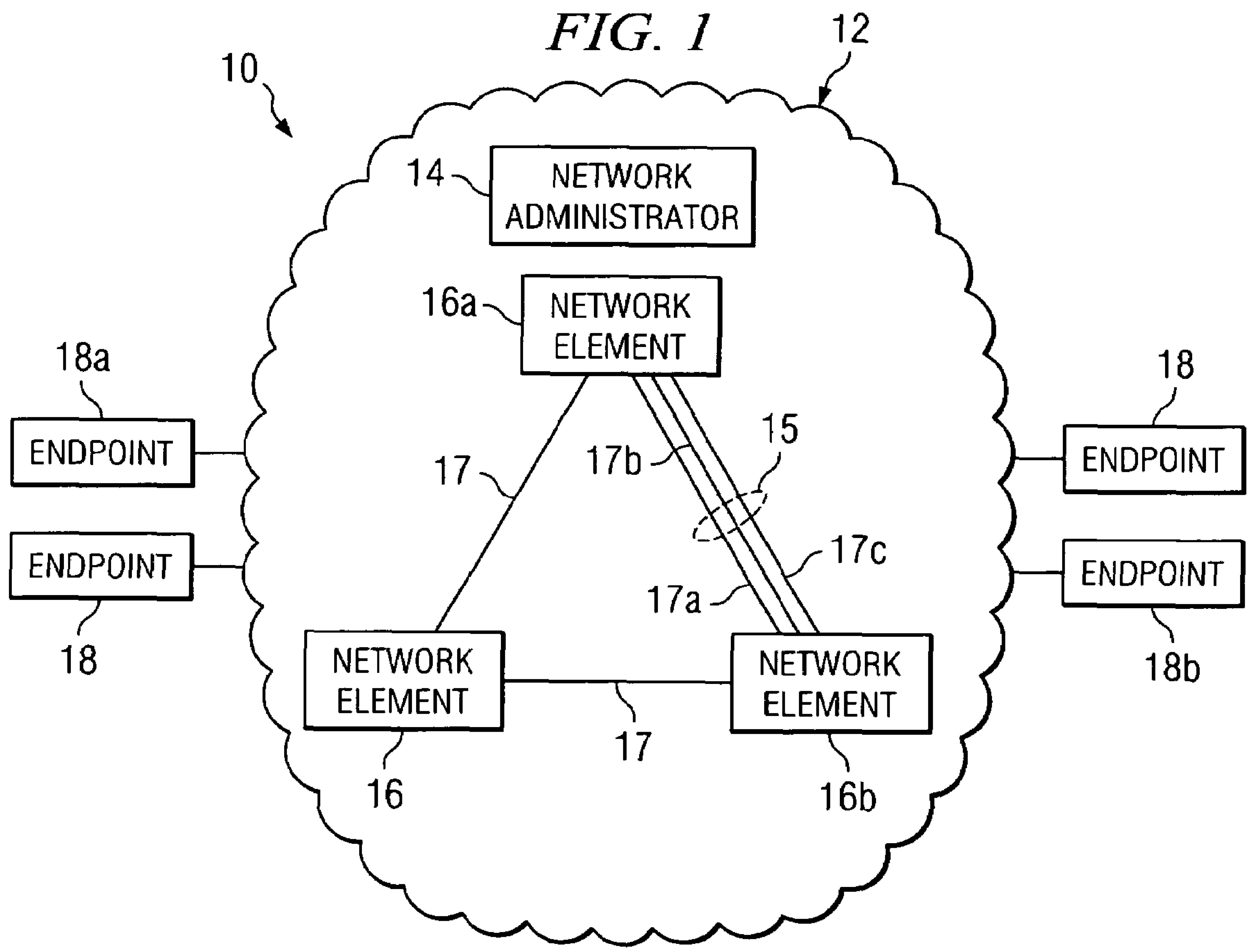
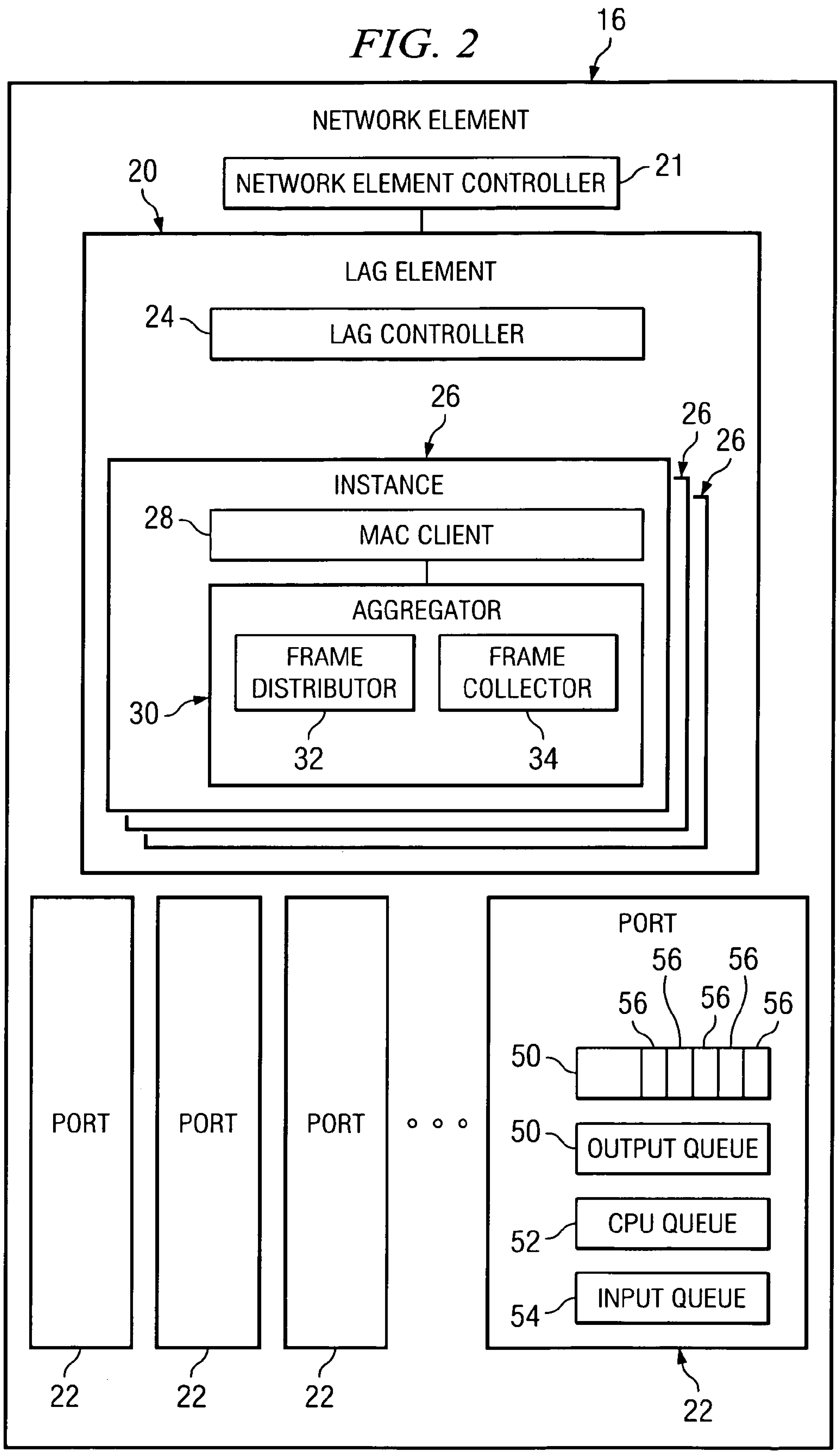

10
12
14
NETWORK ADMINISTRATOR
16a
NETWORK ELEMENT
18a
ENDPOINT
ENDPOINT
18
18
ENDPOINT
ENDPOINT
18b
15
17b
17
17c
17a
NETWORK ELEMENT
NETWORK ELEMENT
17
16
16b

FIG. 2


16
NETWORK ELEMENT
20
NETWORK ELEMENT CONTROLLER
21
LAG ELEMENT
24
LAG CONTROLLER
26
26
26
INSTANCE
28
MAC CLIENT
AGGREGATOR
FRAME DISTRIBUTOR
FRAME COLLECTOR
30
32
34
PORT
PORT
PORT
PORT
56
56
56
56
56
50
50
OUTPUT QUEUE
52
CPU QUEUE
54
INPUT QUEUE
22
22
22
22

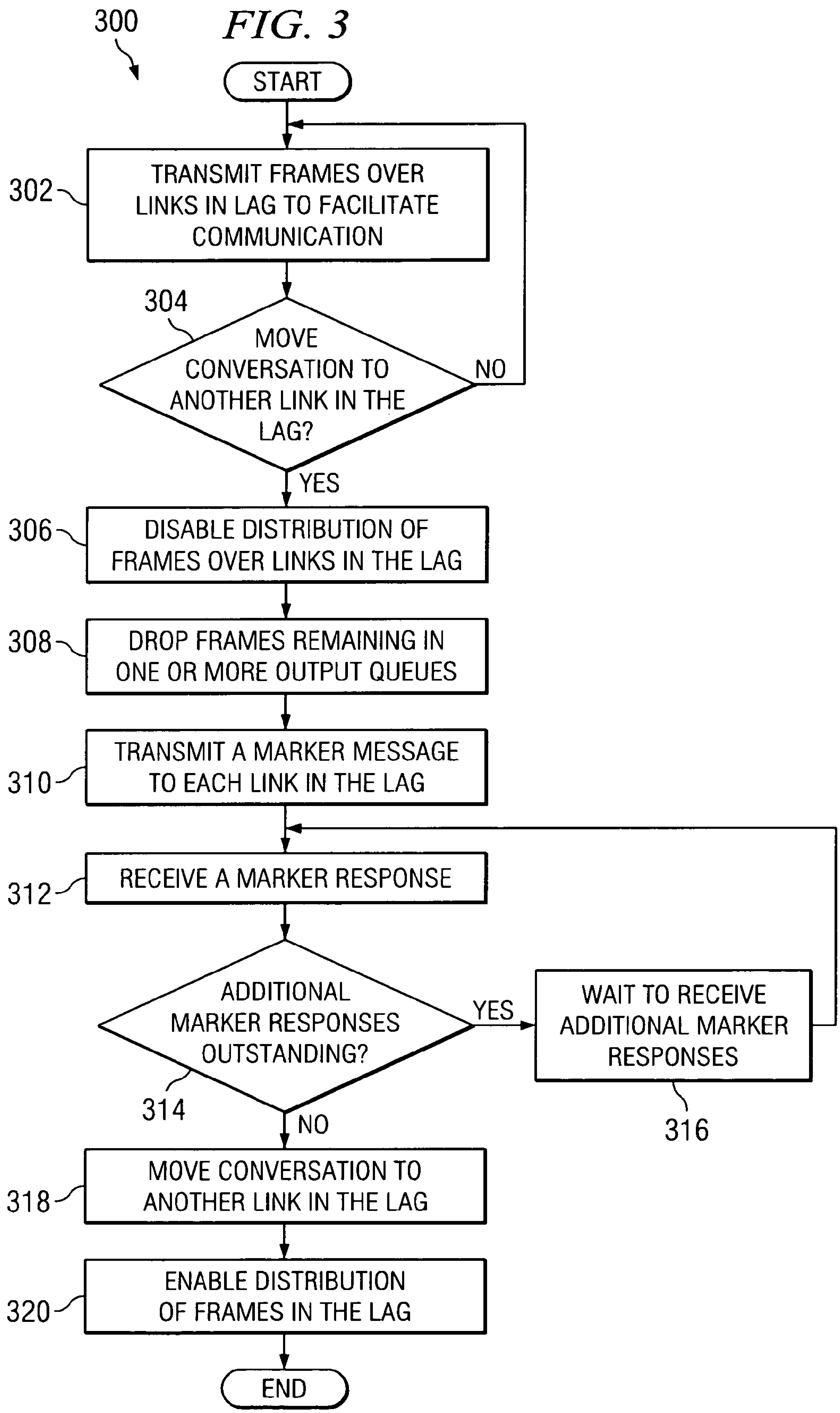
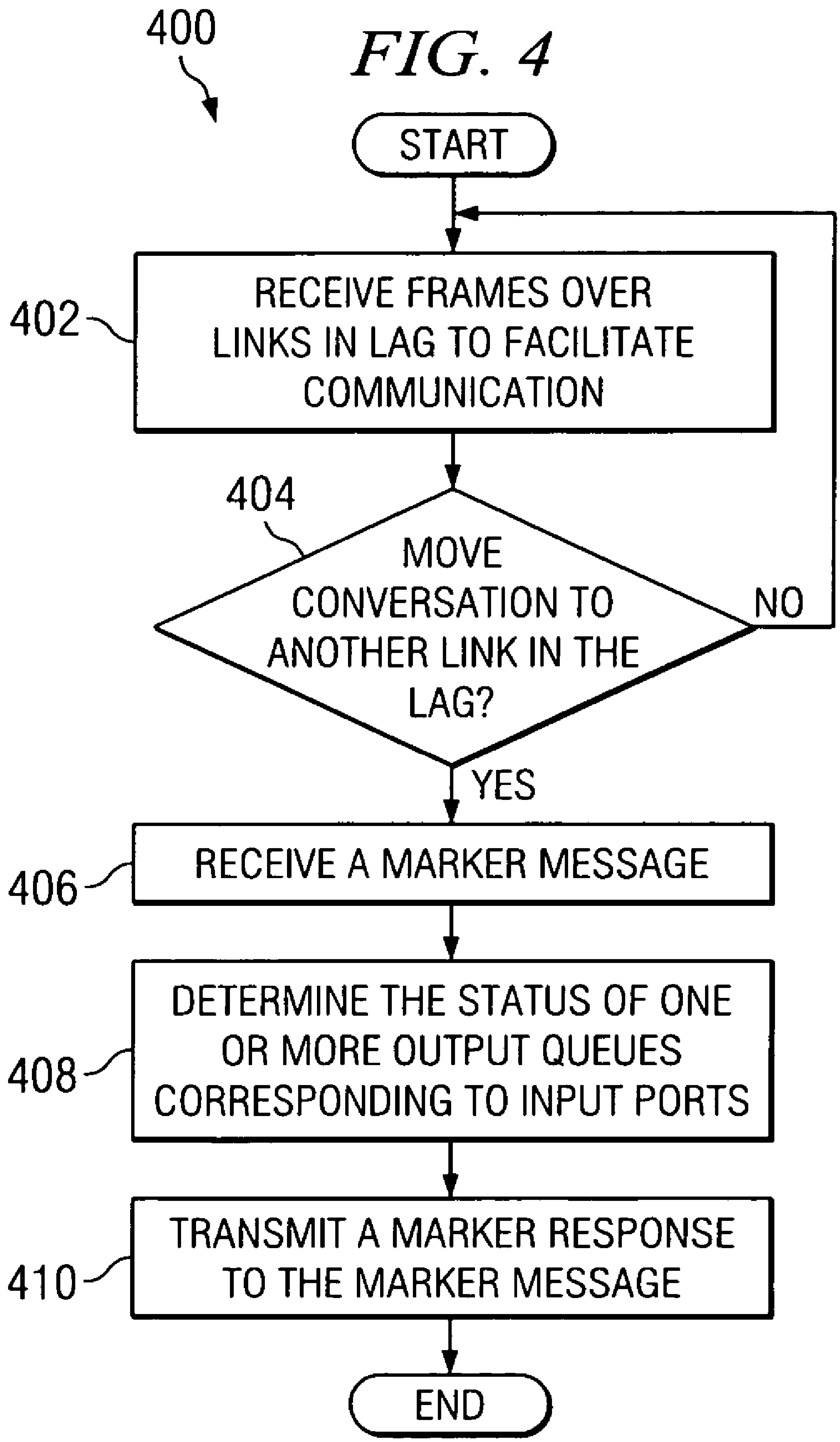

300
START
302
TRANSMIT FRAMES OVER LINKS IN LAG TO FACILITATE COMMUNICATION
304
MOVE CONVERSATION TO ANOTHER LINK IN THE LAG?
NO
YES
306
DISABLE DISTRIBUTION OF FRAMES OVER LINKS IN THE LAG
308
DROP FRAMES REMAINING IN ONE OR MORE OUTPUT QUEUES
310
TRANSMIT A MARKER MESSAGE TO EACH LINK IN THE LAG
312
RECEIVE A MARKER RESPONSE
314
ADDITIONAL MARKER RESPONSES OUTSTANDING?
YES
NO
316
WAIT TO RECEIVE ADDITIONAL MARKER RESPONSES
318
MOVE CONVERSATION TO ANOTHER LINK IN THE LAG
320
ENABLE DISTRIBUTION OF FRAMES IN THE LAG
END

FIG. 3

FIG. 4



400
START
402
RECEIVE FRAMES OVER LINKS IN LAG TO FACILITATE COMMUNICATION
404
MOVE CONVERSATION TO ANOTHER LINK IN THE LAG?
NO
YES
406
RECEIVE A MARKER MESSAGE
408
DETERMINE THE STATUS OF ONE OR MORE OUTPUT QUEUES CORRESPONDING TO INPUT PORTS
410
TRANSMIT A MARKER RESPONSE TO THE MARKER MESSAGE
END

FIG. 5

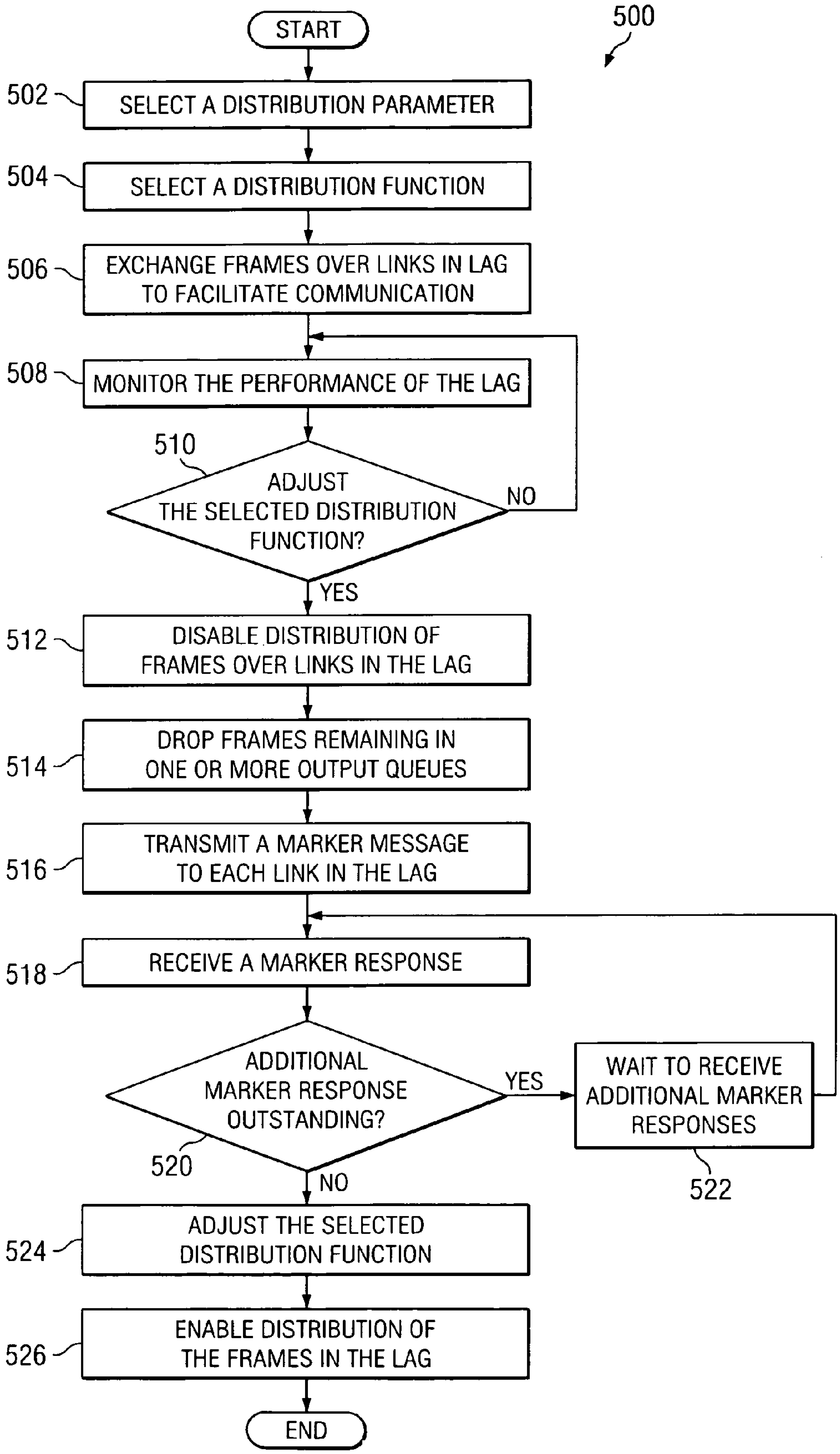

500
START
502
SELECT A DISTRIBUTION PARAMETER
504
SELECT A DISTRIBUTION FUNCTION
506
EXCHANGE FRAMES OVER LINKS IN LAG TO FACILITATE COMMUNICATION
508
MONITOR THE PERFORMANCE OF THE LAG
510
ADJUST THE SELECTED DISTRIBUTION FUNCTION?
NO
YES
512
DISABLE DISTRIBUTION OF FRAMES OVER LINKS IN THE LAG
514
DROP FRAMES REMAINING IN ONE OR MORE OUTPUT QUEUES
516
TRANSMIT A MARKER MESSAGE TO EACH LINK IN THE LAG
518
RECEIVE A MARKER RESPONSE
520
ADDITIONAL MARKER RESPONSE OUTSTANDING?
YES
WAIT TO RECEIVE ADDITIONAL MARKER RESPONSES
522
NO
524
ADJUST THE SELECTED DISTRIBUTION FUNCTION
526
ENABLE DISTRIBUTION OF THE FRAMES IN THE LAG
END

FIG. 6

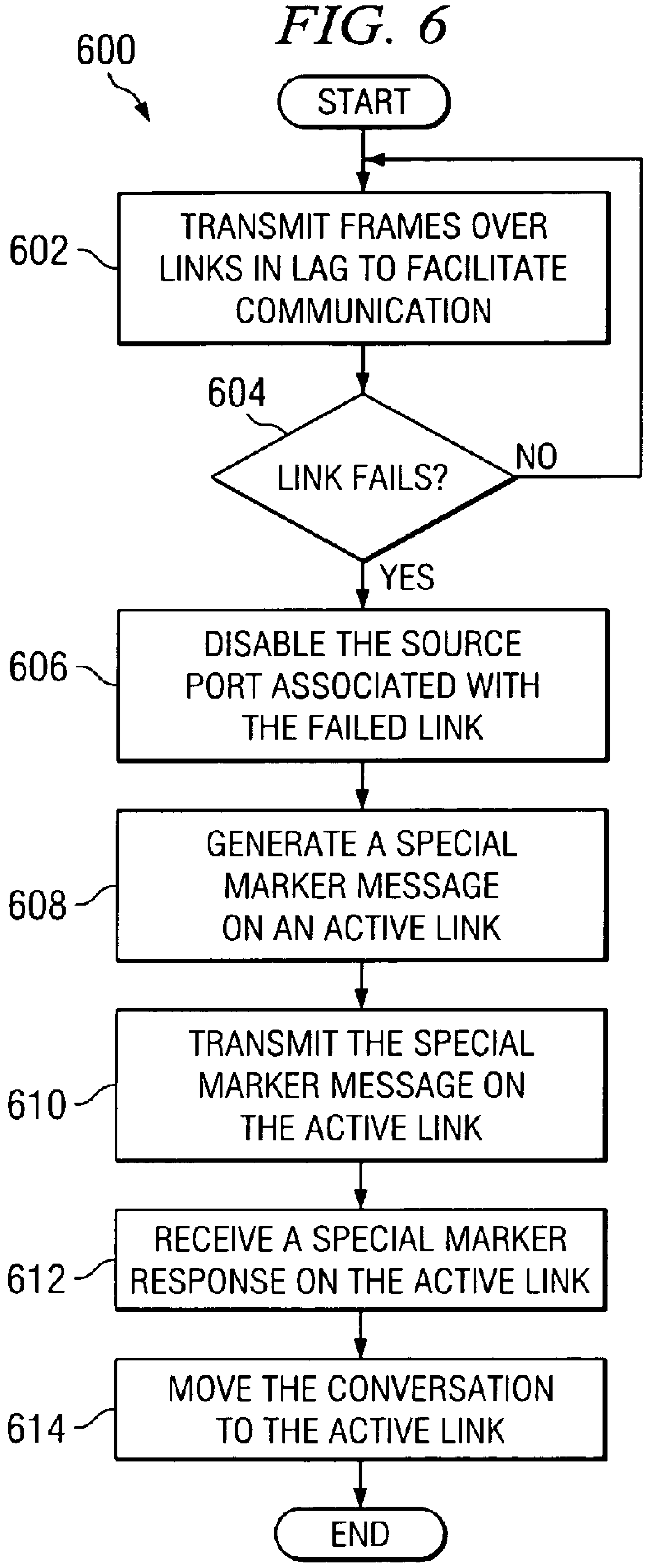
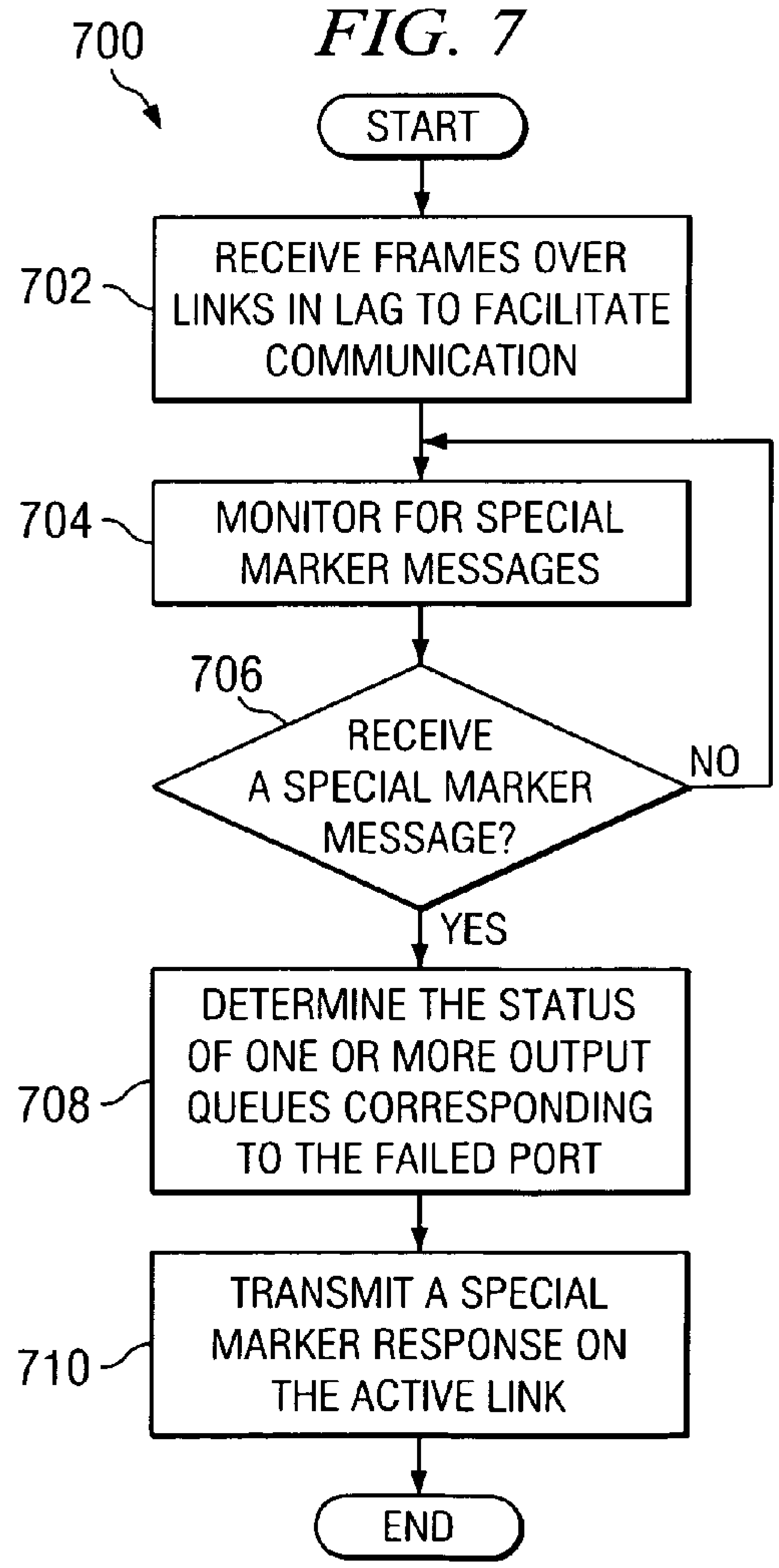

600
START
602
TRANSMIT FRAMES OVER LINKS IN LAG TO FACILITATE COMMUNICATION
604
LINK FAILS?
NO
YES
606
DISABLE THE SOURCE PORT ASSOCIATED WITH THE FAILED LINK
608
GENERATE A SPECIAL MARKER MESSAGE ON AN ACTIVE LINK
610
TRANSMIT THE SPECIAL MARKER MESSAGE ON THE ACTIVE LINK
612
RECEIVE A SPECIAL MARKER RESPONSE ON THE ACTIVE LINK
614
MOVE THE CONVERSATION TO THE ACTIVE LINK
END

FIG. 7


700
START
702
RECEIVE FRAMES OVER LINKS IN LAG TO FACILITATE COMMUNICATION
704
MONITOR FOR SPECIAL MARKER MESSAGES
706
RECEIVE A SPECIAL MARKER MESSAGE?
NO
YES
708
DETERMINE THE STATUS OF ONE OR MORE OUTPUT QUEUES CORRESPONDING TO THE FAILED PORT
710
TRANSMIT A SPECIAL MARKER RESPONSE ON THE ACTIVE LINK
END

PURGE MECHANISM IN LINK AGGREGATION GROUP MANAGEMENT

RELATED APPLICATION

This application claims the benefit under 35 U.S.C. § 119 (e) of U.S. Provisional Application Ser. No. 60/670,369 entitled "Link Aggregation and Network Management Techniques," filed on Apr. 12, 2005 and incorporated by reference herein.

TECHNICAL FIELD OF THE INVENTION

The present invention relates generally to network management and, more particularly, to a purge mechanism in link aggregation group management.

BACKGROUND OF THE INVENTION

A link aggregation group (LAG) combines multiple physical, network links into a single, logical link that provides aggregated throughput and high availability to endpoints. Communication between two endpoints occurs over the single, logical link of the LAG.

SUMMARY OF THE INVENTION

In accordance with the present invention, techniques for moving conversations between links using a purge mechanism are provided.

According to a particular embodiment, method for redistributing conversations among links in a link aggregation group aggregates multiple physical links coupled between a first network element and a second network element as a link aggregation group and distributes received frames among output queues corresponding to each of the physical links, with the frames associated with one or more conversations. The method determines to move at least one of the conversations between the physical links, disables distribution of additional received frames to the output queues corresponding to the physical links, purges frames from the output queues corresponding to the physical links, and transmits a marker messages on the physical links. The method receives a marker response and, in response to receiving the marker response, enables distribution of subsequently received frames among the physical links.

Embodiments of the invention provide various technical advantages. Particular embodiments provide an effective mechanism to move a communication between links using the link aggregation marker protocol. For example, a purge mechanism is provided in combination with the marker protocol that provides for more effectively and efficiently moving the communication between endpoints as opposed to traditional implementations that take longer to move the communication. According to particular embodiments, the purge mechanism further ensures that frames will not be reordered or duplicated when moving the communication from one link to another. According to particular embodiments, using the purge mechanism with the marker protocol provides for increased link availability. This allows for the communication to continue without disruption while being moved between links.

Other technical advantages of the present invention will be readily apparent to one skilled in the art from the following figures, descriptions, and claims. Moreover, while specific advantages have been enumerated above, various embodiments may include all, some, or none of the enumerated advantages.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the present invention and its advantages, reference is now made to the following description, taken in conjunction with the accompanying drawings, in which:

FIG. **1** illustrates a communication system that includes a LAG that implements a purge mechanism in accordance with particular embodiments of the present invention;

FIG. **2** illustrates an example network element from the system of FIG. **1**;

FIG. **3** is a flowchart illustrating a method for moving a conversation between ports with the purge mechanism using a frame distributor at a transmitting network element;

FIG. **4** is a flowchart illustrating a method for responding to a determination to move the conversation between ports with the purge mechanism using a frame collector at a receiving network element;

FIG. **5** is a flowchart illustrating a method for implementing a distribution tuning mechanism for the LAG;

FIG. **6** is a flowchart illustrating a method for implementing a special marker message using the frame distributor at the transmitting network element; and

FIG. **7** is a flowchart illustrating a method for responding to a special marker message using the frame collector at the receiving network element.

DETAILED DESCRIPTION OF THE DRAWINGS

FIG. **1** illustrates a communication system, indicated generally at **10**, that includes a LAG that implements a purge mechanism. Endpoints **18** communicate with each other over network **12** using network elements **16**. In general, network elements **16** provide for the formation of a LAG to enable high speed communications between endpoints **18**. To support the operation of LAGs, network elements **16** may implement techniques including: a purge mechanism to enable quick movement of conversations among links in a LAG, an extended marker protocol to enable effective movement of communications from failed or otherwise inactive links in a LAG, and tuning of distribution algorithms to help support efficient and full use links in a LAG. Network elements **16** may implement some or all of these techniques to support the operation of LAGs.

Network **12** represents communications equipment, including hardware and any appropriate controlling logic, for interconnecting elements coupled to network **12** and facilitating communication between endpoints **18**. Network **12** may include a local area network (LAN), a metropolitan area network (MAN), any other public or private network, a local, regional, or global communication network, an enterprise intranet, other suitable wireline or wireless communication link, or any combination of the preceding. Further, network **12** may include any combination of gateways, routers, hubs, switches, and any other hardware, software, or a combination of the preceding that may implement any suitable protocol or communication.

In the illustrated embodiment, network **12** includes at least one network administrator **14** and multiple network elements **16**. Network administrator **14** monitors and controls the behavior of network elements **16**. For example, network administrator **14** provides configuration information for network elements **16**. In particular, network administrator **14** may provide for the formation and administration of LAGs between network elements **16**. As an example, network administrator **14** may monitor traffic within network **12** and change usage of links **17** and LAGs in response to network conditions.

Network element **16** represents network communications equipment, including appropriate controlling logic, that facilitates the communication between endpoints **18**. For example, network elements **16** may include switches, routers, gateways, servers, or other suitable network equipment. According to particular embodiments, network elements **16** communicate with each other by way of high-speed electrical signals. In the illustrated embodiment, a LAG **15** is formed between network elements **16***a* and **16***b* to provide increased bandwidth and increased availability during communication. According to particular embodiments, network element **16***a* negotiates LAG **15** with another link-aggregation enabled network element **16***b*. To form LAG **15**, one or more physical links **17** between network elements **16** are aggregated together.

Each link **17** represents any suitable channel that provides for the exchange of signals between network elements **16**. Network elements **16** may have multiple communications occurring simultaneously on multiple links **17**. Communications may be moved between links **17** while a communication is ongoing. Endpoints **18** treat LAG **15**, which includes one or more physical links **17**, as a single, logical link for communication. Network elements **16** may be aggregated in any suitable manner, and any suitable number of links **17** may aggregate together to form one or more LAGs **15**. For example, network element **16** may have a total of eight links **17**, with three links **17** aggregated to form a first LAG **15**, another two links **17** aggregated to form a second LAG **15**, and the remaining three links **17** operating separately and not aggregated.

Endpoints **18** represent any suitable device operable to communicate with network **12**. Communication occurs between endpoints **18** by exchanging frames. Endpoints **18** exchange audio, voice, data, video, or other information in system **10** using any suitable communication protocol. Endpoints **18** may be any combination of hardware and/or software that provide communication services to a user. For example, endpoints **18** include a server, a personal computer, such as a laptop or a desktop, an Internet Protocol (IP) telephone, or any suitable device operable to communicate within system **10**.

According to particular embodiments, components within system **10** communicate frames using Ethernet standards. A frame includes any suitable segmentation of data, such as packets, frames, or cells. Moreover, Ethernet and Ethernet standards include communication protocols that have been developed to handle transmission of frames between components, including any extensions, add-ons, and/or future developments that may occur with respect to these protocols. For example, Ethernet standards encompass the protocols set forth within the IEEE 802.3 and supplements.

As noted above, LAGs **15** function as single logical links formed from multiple individual physical links **17** coupling between network elements **16**. During operation, two network elements **16** coupled by a particular LAG **15** may treat that LAG **15** as a single physical connection, potentially with some restrictions. As an example of operation, consider endpoint **18***a* communicating with endpoint **18***b* over network **12**, and links **17***a*-**17***c* between network elements **16***a* and **16***b* aggregated to form LAG **15**. The communication between network element **16***a* and network element **16***b* may be referred to as a conversation. According to particular embodiments, network elements **16** maintain each conversation on a single link **17** within a given LAG **15**. This can help to maintain frame ordering within a conversation. If conversations are unevenly distributed among links **17** in LAG **15**, this can result in poor utilization of the full bandwidth of LAG **15**. In addition, failure of one link **17** will potentially cut off conversations occurring over that link **17**. Thus, in response to link failure, poor link utilization, reconfigurations, or other suitable conditions, conversations may be switched among links **17** within LAG **15**.

During operation, network elements **16** may distribute received frames among links **17** in LAG **15** using any appropriate techniques. According to particular embodiments, network elements **16** implement a distribution algorithm to select a particular link **17** for each received frame. For example, network element **16** may select a particular one of links **17** in LAG **15** based on addressing information, such as source or destination address information, contained in each frame. This type of algorithm can ensure that all frames from one endpoint **18** to another endpoint **18** pass along the same link **17**, and thus can ensure proper ordering of frames. This type of distribution algorithm requires no state-based memory to track distribution of conversations but can result in poor distribution of conversations among links **17**. As an alternative, conversations may be distributed in a round-robin manner to links **17** in LAG **15**. However, using state-based distribution techniques such as the round-robin technique requires memory to operate, since the assignment of conversations among the different links **17** must be tracked.

To reduce the need for state-based distribution techniques while obtaining advantages of even utilization of links **17**, network elements **16** may support a mechanism for tuning the distribution of frames among links **17** in LAG **15**. For example, given underutilization of one or more links **17** in a particular LAG **15**, network element **16** can change the distribution of communications among links **17** in that LAG **15**. According to a particular embodiment, network elements **16** support multiple different distribution algorithms, and network administrator **14** may select between these different algorithms in response to any appropriate network conditions. For example, network elements **16** may each provide multiple different algorithms, with each algorithm calculating a particular link **17** in LAG **15** based on some combination of source and/or destination address information. By using different combinations and portions of addressing information and potentially applying different functions, these algorithms can effect different distributions of frames among links **17** while still maintaining proper frame ordering. Network administrator **14**, either automatically or manually, may change the distribution algorithms used by one or more network elements **16** to combat underutilization of LAGs **15**.

In addition to providing multiple distribution algorithms, network elements **16** may further support the use of distribution parameters in combination with one or more of the distribution algorithms. These parameters can also affect the distribution function resulting from the application of a distribution algorithm. For example, a distribution parameter may shift the portion of an address considered by a particular distribution algorithm. Used in combination, a relatively small number of distribution algorithms and parameters can provide a large number of potential distribution functions.

Given the changing of distribution algorithms or parameters, failure of links **17**, reconfiguration of LAGs **15**, or in other appropriate circumstances, conversations may be moved among lings **17** in LAG **15**. To provide for the rapid movement of communications between links **17** in LAG **15**, network elements **16** may implement a purge mechanism. Alternatively, or in addition, network elements **16** may implement an extended marker protocol in circumstances in which links **17** fail or otherwise become inactive.

For normal movement of communications between links **17** within LAG **15**, network elements **16** may support a marker protocol, which may be based on a standard, such as the Institute of Electrical and Electronics Engineers, Inc. (IEEE) 802.3 Clause 43. Continuing the example from above, assume that the conversation between endpoint **18***a* and endpoint **18***b* involves a stream of frames communicated from endpoint **18***a* to endpoint **18***b*, and that network element **16***a* transmits these frames to network element **16***b* using link **17***a*. In response to a failure of link **17***a*, redistribution of conversations, or other appropriate circumstances, network element **16***a* may determine to move the conversation on link **17***a* to another link **17** in LAG **15**.

To enable quick movement of the conversation (or multiple conversations), network element **16***a* may use a purge mechanism. In an example embodiment, the purge mechanism includes disabling distribution of additional frames to the output queues associated with link **17***a* and potentially the dropping of some or all frames from the output queues associated with link **17***a*. Network element **16***a* sends a message to network element **16***b* regarding moving the conversation. For example, network element **16***a* may send a marker message to network element **16***b* using an administrative queue associated with link **17***a*. When network element **16***b* responds to the message, network element **16** *a* may move the conversation to another link **17** within LAG **15**. The use of marker messages and marker responses can help to ensure the appropriate ordering of frames transmitted on LAG **15**. By implementing the purge mechanism, conversations can be quickly moved between links **17**.

According to particular embodiments, network element **16***a* moves all conversations occurring on link **17***a* using the purge mechanism. For example, network elements **16***a* may move multiple conversations from link **17***a* to link **17***c*, or may spread conversations among two or more other links **17** in the given LAG **15**. In addition, network elements **16** may use the purge mechanism concurrently on multiple different links **17**. For example, network element **16** may use the purge mechanism on all links **17** in LAG **15** in conjunction with the redistribution of conversations among links **17** based on a change in the distribution algorithm.

In conjunction with or in other circumstances, network elements **16** may implement an extended marker protocol to further help to support the movement of communications between links **17**. For example, network elements **16** may use an extended marker protocol if one of links **17** within LAG **15** fails or otherwise becomes inactive. According to particular embodiments, network elements **16** can respond to the failure or inactivation of a particular link **17** within LAG **15** by exchanging a special marker message and special marker response on an active link **17** within LAG **15**. Using these special communications, network elements **16** can quickly move communications from failed links **17** without relying on timeouts or other mechanisms. According to particular embodiments, the special marker messages and responses use fields within traditional marker messages and response, but provide additional information understandable only by appropriately enabled network elements **16**.

More detailed descriptions of particular embodiments for implementing purge mechanisms, extended marker protocols, and distribution tuning are discussed below. However, while specific examples are provided within this description, it should be understood that they are provided for illustrative purposes only, and system **10** contemplates network elements **16** applying any suitable techniques. Moreover, the particular embodiment illustrated and described with respect to system **10** is not intended to be all-inclusive or limiting. While system **10** and elements within system **10** are depicted as having a certain configuration and arrangement of elements, it should be noted that these are logical depictions, and the components and functionality of system **10** may be combined, separated and distributed as appropriate both logically and physically. Also, the functionality of system **10** and elements within system **10** may be provided by any suitable collection and arrangement of components.

FIG. **2** illustrates an example network element **16** from system **10** of FIG. **1**. Network element **16** may include any appropriate combination and arrangement of components and modules. In the illustrated embodiment, network element **16** includes a LAG element **20** that facilitates the formation of LAG **15**, a network element controller **21** to manage the operation of components within network element **16**, and ports **22** that communicate over links **17**, which aggregate to form LAG **15**. LAG element **20** includes a LAG controller **24** and one or more LAG modules **26**. Each LAG module **26** includes a Media Access Control (MAC) client **28** and an aggregator **30**, which includes a frame distributor **32** and a frame collector **34**. Port **22** includes one or more output queues **50**, a central processing unit (CPU) queue **52**, and an input queue **54** that facilitate the communication of frames **56**. In general, the components within network element **16** facilitate the communication between endpoints **18** over network **12**. More specifically, the components within network element **16** provide a purge mechanism that facilitates moving of conversations between links **17** in LAG **15**.

Network element controller **21** represents hardware, including any suitable controlling logic, capable of managing the operation of other components or modules within network element **16**. For example, network element controller **21** may operate to load and execute software or other controlling logic from any suitable source.

Ports **22** represent any suitable physical interface, including appropriate controlling logic, for connecting to components in system **10**. In an embodiment, ports **22** represent the physical interface between network elements **16**. Ports **22** that transmit communications to other ports **22** may be referred to as source ports **22**. Alternatively, ports **22** that receive communications from other ports **22** may be referred to as destination ports **22**. Any port **22** may behave as a source port **22** and a destination port **22** during communication when information is exchanged bidirectionally. Ports **22** may include any suitable state of operation. For example, ports **22** may have a disabled state, a learning state, and a forwarding state. The learning state may occur when a frame comes into port **22**, and the forwarding state may occur during normal traffic operation when frames come in and go out of port **22**. Network element **16** includes any suitable number of ports **22**. Each port **22** may have an associated physical address. For example, each port **22** may be assigned a unique, globally administered MAC address. Ports **22** may be coupled by links **17**, which represent a communication channel between ports **22**. Each port **22** may correspond to one link **17**. Communications between endpoints **18** may be moved among links **17** within LAG **15**. Moving communications between links **17** provides for, among other things, load balancing and maintaining the availability of the conversation if one or more links **17** in LAG **15** fail.

The queues within port **22** further facilitate communications. Output queues **50** receive frames **56** from frame distributor **32** and holds frames **56** for transmission to network element **16**. According to particular embodiments, output queue **50** provides for transmitting frames **56** on a first-in-first-out basis. Input queue **54** receives frames **56** and messages from network element **16** and provides frames **56** and messages to frame collector **34**. CPU queue **52** provides messages and responses in the marker protocol and the extended marker protocol for moving the conversation among links **17** in LAG **15**.

Element **20** represents any suitable combination of hardware and/or software that facilitates link aggregation. Element **20** includes controller **24** and one or more modules **26**. Controller **24** represents hardware, including any suitable controlling logic, capable of managing the operation of other components or modules within LAG element **20**. For example, controller **24** facilitates the creation of LAG **15**, monitors the behavior of an existing LAG **15**, and provides any suitable functionality to facilitate link aggregation. In particular embodiments, controller **24** determines which links **17** may be aggregated, aggregates links **17**, binds ports **22** to aggregator **30**, and monitors LAG **15**. In another embodiment, network administrator **14** manually controls the variables of link aggregation.

Each negotiated LAG **15** has an associated module **26**, which may be a logical depiction, in element **20**. Module **26** facilitates functionality of its associated LAG **15** and provides for the implementation of varying features within LAG **15**. For example, when links **17** are active, communications occurring on link **17***a* within LAG **15** may be moved to link **17***c* using module **26**. As another example, if link **17***a* fails during communication, the communication on link **17***a* may be moved to link **17***c* using module **26**.

Each module **26** includes a MAC client **28** and an aggregator **30**. MAC client **28** represents the logical media access controller for LAG **15**, and aggregator **30** supports the communication of frames over links **17** and the implementation of features within LAG **15**. To support the transmission and receipt of frames **56** between network elements **16**, aggregator **30** is bound to one or more ports **22**.

While frames **56** are transmitted and received by aggregator **30**, the order of frames **56** is maintained during the communication. Frame distributor **32** and frame collector **34** facilitate the communication of frames **56**. Frame distributor **32** distributes frames **56** from endpoints **18** over port **22** using links **17** that form LAG **15**. Frame distributor **32** ensures frames **56** of a particular conversation are passed to port **22** to prevent misordering of frames **56**. Frame distributor **32** implements any suitable distribution algorithm that chooses link **17** to use for the transmission of any given frame **56** or set of frames **56** that belong to a conversation. The selected distribution algorithm may prevent misordering of frames **56** of a conversation and the duplication of frames **56**. Based on the selected distribution algorithm, frames of a given conversation are forwarded to port **22**. The distribution algorithm may be based on a destination address, a source address, a combination of the destination address and the source address, the address of the receiving port **22**, or any other appropriate criteria.

Frame collector **34** receives frames **56** from ports **22** and delivers the received frames **56** towards endpoint **18**. According to particular embodiments, frames **56** are forwarded out another port **22**, which may directly connect to endpoint **18** or may be on the path. For example, frame collector **34** receives frames **56** from a set of links **17** that form LAG **15**. For any given port **22**, frame collector **34** passes frames **56** to MAC client **28** in the order received from port **22**. Frame collector **34** may select frames **56** received from aggregated ports **22** in any order. Because frame distributor **32** ensures frames **56** maintain their order, frame collector **34** may not need to perform any reordering of frames **56** received from multiple links **17** and frame ordering is maintained for the communication.

As discussed above, network elements **16** support a marker protocol and an extended marker protocol. Both protocols provide for communications among aggregations. Using these protocols, for example, frame distributor **32** of network element **16***a* generates and distributes a marker, using marker protocol or the extended marker protocol, to frame collector **34** of network element **16***b*. Frame collector **34** of network element **16***b* distributes a marker response, using marker protocol or extended marker protocol, to frame distributor **32** of network element **16***a*.

Messages, including a marker and a marker response, in marker protocol may have any suitable format. As discussed above, marker protocol provides for moving conversations between links **17** within LAG **15**. Using marker protocol, controller **24** generates and transmits a marker on one or more active links **17** within LAG **15**. Frame collector **34** in the receiving network element **16** provides a maker response to frame distributor **32** in the transmitting network element **16**. During the process of moving conversations from one link **17**, conversations on other links **17** may continue without interruption. Alternatively, network element **16** may use the marker protocol to shift conversations among two or more links **17** in the associated LAG **15**. For example, controller **24** may generate and transmit marker messages on one or more links **17** and, after receiving responses, move conversations occurring on those links **17**.

The marker and marker response in the extended marker protocol (or a special marker and a special marker response, respectively) may have any suitable format. In an exemplary embodiment, a message in the extended marker protocol includes the following format:

Destination Address = MAC address of the destination port
Source Address = MAC address of a non-failed source port
Type = 0x8809
Subtype = Marker Protocol
Version = 0x01
TLV: Marker Information = 0x01, Marker Response = 0x02,
Special Marker = 0x03, Special Marker Response = 0x04
Information Length = 0x10 (16_{10})
Requester Port
Requester System
Requester Transaction ID = Failed port for special messages
Pad = 0x0000
Terminator = 0x00
Terminator Length = 0x00
Reserved
Frame Check Sequence

As discussed above, the extended marker protocol may be used when link **17** fails, or is otherwise inactivated, and conversations are to be moved to one or more active links **17**. In accordance with one embodiment of the extended marker protocol, frame distributor **32** in network element **16***a* provides a special marker on an active link **17** within LAG **15**. Frame collector **34** in network element **16***b* provides a special marker response to frame distributor **32**. During the process of moving conversations from one link **17**, conversations on other links **17** may continue without interruption. In the alternative, network element **16** may use the extended marker protocol to shift conversations among two or more links **17** in the associated LAG **15**. For example, controller **24** may generate and transmit marker messages on one or more links **17** and, after receiving responses, move conversations occurring on those links **17**.

In accordance with one embodiment, the extended marker protocol provides for identifying the failed or inactive link **17** in the message. For example, the message format may include the MAC address of port **22** associated with failed link **17** in the Requester Transaction ID field. As another example, the TLV field provides for identifying the message as a special marker or a special marker response. Using the extended marker protocol, frame distributor **32** generates the special marker using an active link **17** within LAG **15**. Frame collector **34** transmits a special marker response to frame distributor **32**, which confirms there are no ongoing frames **56** before moving the conversations. During the process of moving the conversations from failed or inactive link **17**, communications on other links **17** may continue without interruption.

While the embodiment illustrated and the preceding description focus on a particular embodiment of network element **16**, system **10** contemplates network element **16** having any suitable combination and arrangement of components and modules supporting a purge mechanism in LAG **15**. Thus, the functionalities performed by the particular elements illustrated may be separated or combined as appropriate, and some or all of these elements may be implemented by logic encoded in media. For example, the functions of frame distributor **32** and frame collector **34** may be separated and/or combined as appropriate and any of their operations may be implemented by suitable control logic. Also, while shown as a single module, the functionalities of some or all of the illustrated components of network element **16** may be distributed among other elements of system **10**.

FIG. **3** is a flowchart **300** illustrating a method for moving a conversation between ports **22** with the purge mechanism using frame distributor **32** at transmitting network element **16**. The following description of flowchart **300** is provided with reference to frame distributor **32** of network element **16** as described above. However, any appropriate element or combination of elements may implement the steps as described below.

To facilitate communication between endpoints **18** using LAG **15**, frame distributor **32** transmits frames **56** over links **17** in LAG **15** at step **302**. During communication, it is determined whether to move one or more conversations to another link **17** in LAG **15** at step **304**. If the conversations are not to be moved, frame distributor **32** continues to distribute frames **56** over links **17** in LAG **15**. On the other hand, if it is determined to move the conversations, frame distributor **32** disables distribution of frames **56** over links **17** in LAG **15** at step **306**. For example, disabling distribution prevents additional frames **56** from being placed in output queue **50**. Frame distributor **32** goes into a purge state and causes the remaining frames **56** in output queues **50** to be dropped at step **308**. During this purge state, frame distributor **32** may discard all frames **56** intended for the disabled link **17**, counting on upper layer recovery mechanisms to handle the dropped frames. Accordingly, CPU queue **52** may begin sending messages in the marker protocol without waiting for the transmission of remaining frames **56** in output queue **50**. According to particular embodiments, during the purge state, output queues **50** may continue to process and transmit control frames, such as bridge protocol data unit (BPDU) frames.

At step **310**, frame distributor **32** transmits a marker message to each link **17** in LAG **15**. For example, frame distributor **32** generates the marker messages and places the marker messages in each CPU queue **52** for transmission on links **17**. The marker message may include any suitable information to inform network element **16** that the communication may be moved from one link **17** in LAG **15** to another link **17** in LAG **15**. According to the example format of a message in the marker protocol provided above, if the TLV has a value of 0x01, the message is identified as a marker message.

Frame distributor **32** receives a marker response at step **312**. It is determined at step **314** whether additional marker responses are outstanding. If frame distributor **32** may receive additional responses, the method proceeds to step **316** and frame distributor **32** waits to receive additional marker responses. From step **316**, additional marker responses may be received at step **312**, and the method continues. In an embodiment, frame distributor **32** waits to receive marker responses from each link **17** that received a marker message. In this embodiment, frame distributor **32** waits varying periods of time depending on the number of additional, outstanding marker responses. In another embodiment, frame distributor **32** initiates a timer while waiting to receive additional marker responses. Frame distributor **32** may use the timer to provide a configurable amount of time when waiting for additional marker responses. The timer may be configured for any suitable period. Using the timer, frame distributor **32** would discontinue waiting for additional marker responses, even if additional marker responses are outstanding.

However, if additional marker responses are not outstanding, the method proceeds to step **318**. At step **318**, the conversation is moved to another link **17** in LAG **15**. Frame distributor **32** returns to a non-purge state and enables distribution of frames **56** in LAG **15** at step **320**. Conversations then continue over active links **17** in LAG **15**.

The preceding flowchart **300** illustrates an exemplary operation for frame distributor **32** in network element **16** to move one or more conversations between ports **22** using the purge mechanism. However, the preceding flowchart **300** and accompanying description illustrate only an exemplary method of operation. Thus, many of the steps in flowchart **300** may take place simultaneously and/or in different orders than as shown. In addition, frame distributor **32** may use methods with additional steps, fewer steps, and/or different steps, so long as the methods remain appropriate.

FIG. **4** is a flowchart **400** illustrating a method for responding to a determination to move the conversation between ports **22** with the purge mechanism using frame collector **34** at receiving network element **16**. The following description of flowchart **400** is provided with reference to frame collector **34** of network element **16** as described above. However, any appropriate element or combination of elements may implement the actions as follows.

To facilitate communication between endpoints **18** using LAG **15**, frame collector **34** receives frames **56** over links **17** in LAG **15** at step **402**. During communication, it is determined whether to move the communication to another link **17** in LAG **15** at step **404**. If the conversation is not to be moved, frame collector **34** continues to receive frames **56** over links **17** in LAG **15**. On the other hand, if it is determined to move the conversation, frame collector **34** receives a marker message at step **406**. For example, a determination is made to move the conversation to another link **17** in LAG **15**, and frame distributor **32** sends a marker message to frame collector **34** in another network element **16**. At step **408**, frame collector **34** determines the status of one or more output queues **50** corresponding to one or more input ports **22**. For example, controller **24** checks the status of output queues **50** using an interrupt or by reading an output queue status register. Additionally, frame collector **34** may determine the status of output queues **50** corresponding to each input port **22**.

At step **410**, frame collector **34** transmits a marker response to frame distributor **32**. The marker response includes any suitable information that responds to the marker message to move the communication between links **17**. For example, the marker response confirms there are no frames **56** to be processed before moving the communication. According to the example format of a message in the marker protocol, if the TLV has a value of 0x02, the message is identified as a marker response.

As with flowchart **300**, flowchart **400** and the accompanying description illustrate only an exemplary method of operation, and frame collector **34** and/or other suitable components contemplate using any suitable techniques to move communication between ports **22** using the purge mechanism. Thus, many of the steps in flowchart **400** may take place simultaneously and/or in different orders as shown. In addition, frame collector **34** may use methods with additional steps, fewer steps, and/or different steps, so long as the methods remain appropriate.

FIG. **5** is a flowchart **500** illustrating a method for implementing a distribution tuning mechanism in LAG **15**. The following description of flowchart **500** is provided with reference to network element **16** as described above. However, any appropriate element or combination of elements may implement the steps as described below.

To facilitate communication between endpoints **18** using LAG **15**, a distribution parameter is selected at step **502**. Multiple distribution parameters may be provided to use in determining how to distribute the conversation among links **17**. Any suitable distribution parameter may be selected. For example, distribution parameters include a measurement of link activity, the configuration of system **10**, or the status of network element **16**. Any suitable element of system **10** may select the distribution parameter, for example, network element **16** or network administrator **14** may select the distribution parameter. Upon selecting the distribution parameter, a distribution function is selected at step **504**. The distribution function provides for distributing conversations among links **17** according to the selected distribution parameter. In an embodiment, each distribution parameter is associated with one or more distribution functions. In this embodiment, the distribution function is selected from among the associated distribution functions. Any distribution function associated with the selected distribution parameter may be selected. As with the distribution parameter, any suitable element of system **10** may select the distribution function, such as network element **16** or network administrator **14**. At step **506**, network element **16** exchanges frames **56** over links **17** in LAG **15**.

The selected distribution parameter and the distribution function may be adjusted during communication. The performance of LAG **15** is monitored during step **508**. Monitoring the performance includes monitoring any suitable parameter of system **10**, such as the activity over links **15** or the effectiveness of exchanging frames **56** between ports **22**. For example, the parameter as determined by the selected distribution parameter is monitored. If the measurement of link activity is selected as the distribution parameter, link activity is monitored during step **508**. At step **510**, it is determined whether to adjust the selected distribution function. For example, network administrator **14** may detect that conversations are unevenly distributed among links **17** within LAG **15**. If it is determined not to adjust the selected distribution function, the performance of LAG **15** continues to be monitored from step **508**.

Alternatively, if it is determined to adjust the selected distribution function, network element **16** initiates the process for implementing the distribution-tuning mechanism. For example, the distribution function may be adjusted if the performance of LAG **15** may be improved by using a different distribution function. As an example, if the measurement of link activity is the selected distribution parameter, network element **16** may adjust the distribution function if link **17** is underutilized. At step **512**, network element **16** disables distribution of frames **56** over links **17** in LAG **15**. For example, disabling distribution prevents additional frames **56** from being placed in output queue **50**. At step **514**, network element **16** drops frames **56** remaining in output queues **50**. Accordingly, CPU queue **52** may begin sending messages in the marker protocol without waiting for the transmission of remaining frames **56** in output queue **50**. While frames **56** are being dropped, output queues **50** may continue to process and transmit control frames, such as BPDU frames.

At step **516**, network element **16** transmits a marker message to each link **17** in LAG **15**. For example, network element **16** generates the marker message, and CPU queue **52** sends the marker message. The marker message may include any suitable information to inform the destination network element **16** that conversations may be redistributed among links **17**. According to the example format of a message in the marker protocol, if the TLV has a value of 0x01, the message is identified as a marker message.

Network element **16** receives a marker response at step **518**. It is determined at step **520** whether additional marker responses are outstanding. If network element **16** may receive additional responses, the method proceeds to step **522** and network element **16** waits to receive additional marker responses. From step **522**, additional marker responses may be received at step **518**, and the method continues. In an embodiment, network element **16** waits to receive marker responses from each link **17** that received a marker message. In this embodiment, network element **16** waits varying periods of time depending on the number of additional outstanding marker responses. In another embodiment, network element **16** initiates a timer while waiting to receive additional marker responses. Network element **16** may use the timer to provide a configurable period to wait for additional marker responses. The timer may be configured for any suitable period. Using the timer, network element **16** would discontinue waiting for additional marker responses when the timer expires even if additional marker responses are outstanding. In yet another embodiment, network element **16** may retransmit marker messages on links **17** on which marker responses remain outstanding.

However, if additional marker responses are not outstanding, the method proceeds to step **524**. At step **524**, the selected distribution function is adjusted. As mentioned above, adjusting the selected distribution function to another distribution function associated with the distribution parameter may improve the performance of LAG **15**. Using the marker protocol, the ordering of frames **56** within a conversation may be maintained even though the distribution function is adjusted. As noted above, any suitable element of system **10** may adjust the selected distribution function. For example, network administrator **14**, either automatically or through manual intervention, may adjust the distribution function. As another example, an automated administrative tool detects the performance of LAG **15** and automatically adjusts LAG **15** by varying the selected distribution function. After adjustment of the distribution among links **17**, network element **16** enables distribution of frames **56** in LAG **15** at step **526**. The conversations continue over links **17** in LAG **15** based on the adjusted distribution function.

The preceding flowchart **500** illustrates an exemplary operation for network element **16** to implement a distribution tuning mechanism in LAG **15**. However, the preceding flowchart **500** and accompanying description illustrate only an exemplary method of operation. For example, network element **16** may adjust the distribution parameter based on the monitoring of the performance of LAG **15**. Adjusting the distribution parameter also provides for improving the performance of LAG **15** by distributing the conversations differently among link **17**. As another example, network element **16** adjusts the distribution parameter and the distribution function to improve the performance of LAG **15**. Many of the steps in flowchart **500** may take place simultaneously and/or in different orders than as shown. In addition, network element **16** may use methods with additional steps, fewer steps, and/or different steps, so long as the methods remain appropriate.

FIG. **6** is a flowchart **600** illustrating a method for implementing a special marker message using frame distributor **32** at transmitting network element **16**. The following description of flowchart **600** is provided with reference to frame distributor **32** of network element **16** as described above. However, any appropriate element or combination of elements may implement the steps as described below.

To facilitate communication between endpoints **18** using LAG **15**, frame distributor **32** transmits frames **56** over links **17** in LAG **15** at step **602**. Frame distributor **32** monitors for failure or other inactivation of links **17** at step **604**. If links **17** do not fail, frame distributor **32** continues to distribute frames **56** over links **17** in LAG **15**. On the other hand, if a particular link **17** does fail, frame distributor **32** disables source port **22** associated with the failed link **17** at step **606**.

At step **608**, frame distributor **32** generates a special marker message on an active link **17**. The special marker message provides for moving the conversation to an active link using the extended marker protocol. Frame distributor **32** transmits the special marker message on active link **17** in LAG **15** at step **610**. For example, frame distributor **32** generates the special marker message, and CPU queue **52** sends the special marker message. The special marker message may include any suitable information to inform network element **16** that link **17** has failed and the communication will be moved to one or more active links **17**. According to the example format of a message in the extended marker protocol, if the TLV has a value of 0x03, the message is identified as a special marker message. Also, the exemplary format as described above also provides the MAC address of the failed port **22** in the Requester Transaction ID field.

Frame distributor **32** receives a special marker response at step **612**. According to the example format of a message in the extended marker protocol, if the TLV has a value of 0x04, the message is identified as a special marker response. The conversation is moved to one of the active links **17** at step **614**. Frame distributor **32** enables distribution of frames **56** in LAG **15**, and the conversations continue over links **17** in LAG **15**.

The preceding flowchart **600** illustrates an exemplary operation for implementing a special marker message using a frame distributor **32** of the network element **16**. However, the preceding flowchart **600** and accompanying description illustrate only an exemplary method of operation. For example, frame distributor **32** removes the failed link **17** from LAG **15** when the conversation is moved to an active link **17** in LAG **15**. Removing failed link **17** provides for moving conversations to an active link **17** while other conversations on other links **17** remain the same. As another example, extended marker protocol may be used in combination with marker protocol. In this example, conversations may be redistributed among active links **17**. Many of the steps in flowchart **600** may take place simultaneously and/or in different orders than as shown. In addition, frame distributor **32** may use methods with additional steps, fewer steps, and/or different steps, so long as the methods remain appropriate.

FIG. **7** is a flowchart **700** illustrating a method for responding to the special marker message using frame collector **34** at receiving network element **16**. The following description of flowchart **700** is provided with reference to frame collector **34** of network element **16** as described above. However, any appropriate element or combination of elements may implement the actions as follows.

To facilitate communication between endpoints **18** using LAG **15**, frame collector **34** receives frames **56** over links **17** in LAG **15** at step **702**. Frame collector **34** monitors for special marker messages at step **704**. For example, in conjunction with normal handling of management messages received on links **17**, frame collector **34** may detect a special marker message sent from frame distributor **32** of a remote network element **16** to inform frame collector **34** of a failed or inactive link **17**. If a special marker message is not received at step **706**, frame collector **34** continues to monitor for special marker messages at step **704**. If a special marker message is received, the method continues to step **708**.

At step **708**, frame collector **34** determines the status of one or more output queues **50** corresponding to port **22** associated with failed link **17**. For example, controller **24** checks the status of output queues **50** using an interrupt or by reading an output queue status register. At step **710**, frame collector **34** transmits a special marker response to frame distributor **32** at the transmitting network element **16**. The special marker response includes any suitable information that responds to the special marker message to move the conversation between links **17** following failure of link **17**. For example, the special marker response confirms there are no frames **56** to be processed before moving the conversation. According to the example format of a message in the extended marker protocol, if the TLV has a value of 0x04, the message is identified as a special marker response. Also, the exemplary format as described above also provides the MAC address of the failed port **22** in the Requester Transaction ID field.

Flowchart **700** and the accompanying description illustrate only an exemplary method of operation, and frame collector **34** and/or other suitable components contemplate using any suitable techniques to respond to the special marker message in link aggregation marker protocol. Thus, many of the steps in flowchart **700** may take place simultaneously and/or in different orders as shown. In addition, frame collector **34** may use method with additional steps, fewer steps, and/or different steps, so long as the methods remain appropriate.

Although the present invention has been described in several embodiments, a myriad of changes and modifications may be suggested to one skilled in the art, and it is intended that the present invention encompass such changes and modifications as fall within the scope of the present appended claims.

What is claimed is:

1. A method for redistributing conversations among links in a link aggregation group comprising:

aggregating a plurality of physical links coupled between a first network element and a second network element as a link aggregation group;

distributing received frames among output queues, wherein each output queue corresponds to a physical link and the frames associate with a plurality of conversations such that all frames from any given one of the conversations map to a particular one of the output queues and the corresponding physical link;

disabling distribution of additional received frames to the output queues;

transmitting a marker message on each physical link in the link aggregation group;

purging frames remaining in the output queues from the output queues;

receiving a marker response; and

in response to receiving the marker response, enabling distribution of subsequently received frames among the physical links.

2. The method of claim **1**, further comprising:

prior to enabling distribution of the subsequently received frames among the physical links, receiving marker responses on each of the physical links.

3. The method of claim **1**, wherein distributing the frames among the output queues comprises distributing the frames among the output queues according to a distribution algorithm, further comprising:

adjusting the distribution algorithm; and

enabling distribution of subsequently received frames among the physical links according to the adjusted distribution algorithm.

4. The method of claim **1**, wherein transmitting the marker message comprises transmitting the marker message using an administrative queue associated with the physical link.

5. The method of claim **1**, further comprising:

receiving a remotely transmitted marker message at a port corresponding to one of the physical links;

monitoring queues corresponding to the port; and

transmitting a marker response on the physical link corresponding to the port in response to the monitoring of the queues corresponding to the port.

6. The method of claim **5**, further comprising transmitting the marker response on the physical link corresponding to the port in response to all frames in the queues corresponding to the port having been processed.

7. The method of claim **1**, wherein the disabling of distribution of additional received frames to the output queues and the purging of frames remaining in the output queues from the output queues result in dropping frames intended for the physical links such that dropped frames must be retransmitted.

8. The method of claim **1**, wherein transmitting the marker message and purging frames remaining in the output queues occurs simultaneously.

9. A network element comprising:

a plurality of ports;

an aggregator associated with two or more of the ports aggregated to form a link aggregation group, the aggregator comprising a frame distributor and a frame collector, wherein the frame collector is operable to receive inbound frames received on the aggregated ports, and the frame distributor is operable to distribute outbound frames among output queues, of the conversations map to a particular one of the output queues and the corresponding aggregated port;

a controller operable to determine to move one or more of the conversations within the link aggregation group, wherein the controller is further operable to disable distribution of additional received frames to the output queues; and

wherein the frame distributor is further operable to transmit a marker message on each aggregated port, to purge frames remaining in the output queues from the output queues, the frame collector is further operable to receive a marker response, and in response to receiving the marker response, the frame distributor is further operable to enable distribution of subsequently received frames among the aggregated ports.

10. The network element of claim **9**, wherein:

the frame collector is further operable, prior to the frame distributor enabling distribution of the subsequently received frames among the physical links, to receive marker responses on each of the physical links.

11. The network element of claim **9**, wherein the frame distributor is further operable to distribute outbound frames among the output queues corresponding to each of the aggregated ports according to a distribution algorithm, to adjust the distribution algorithm, and to enable distribution of the subsequently received frames among the aggregated ports according to the adjusted distribution algorithm.

12. The network element of claim **8**, wherein the frame collector is further operable to:

receive a remotely transmitted marker message at one of the aggregated ports;

monitor queues corresponding to the aggregated port receiving the remotely transmitted marker message; and

transmit a marker response on the aggregated port receiving the remotely transmitted marker message in response to the monitoring of the queues.

13. The network element of claim **12**, further comprising transmitting the marker response on the aggregated port receiving the remotely transmitted marker message in response to all frames in the queues corresponding to the aggregated port having been processed.

14. The network element of claim **8**, wherein the disabling of distribution of additional received frames to the output queues and the purging of frames remaining in the output queues from the output queues result in dropping frames intended for the physical links such that dropped frames must be retransmitted.

15. The network element of claim **9**, wherein the frame collector is further operable to:

receive a remotely transmitted marker message on one of the physical links;

determine a status of queues corresponding to the physical link transmitting the remotely transmitted maker message; and

transmit a marker response on the physical link transmitting the remotely transmitted maker message.

16. A computer readable medium encoding software for redistributing conversations among links in a link aggregation group, which when executed by a computer, causes the computer to perform the steps of:

aggregating a plurality of physical links coupled between a first network element and a second network element as a link aggregation group;

distributing received frames among output queues, wherein each output queue corresponds to a physical link and the frames associate with a plurality of conversations such that all frames from any given one of the conversations map to a particular one of the output queues and the corresponding physical link;

disabling distribution of additional received frames to the output queues;

transmitting a marker message on each physical link in the link aggregation group;

purging frames remaining in the output queues from the output queues;

receiving a marker response; and

in response to receiving the marker response, enabling distribution of subsequently received frames among the physical links.

17. The computer readable medium of claim **16**, further operable when executed to perform the steps of:

prior to enabling distribution of the subsequently received frames among the physical links, receiving marker responses on each of the physical links.

18. The computer readable medium of claim **16**, wherein distributing the frames among the output queues comprises distributing the frames among the output queues according to a distribution algorithm, the logic further operable when executed to perform the steps of:

adjusting the distribution algorithm; and

enabling distribution of subsequently received frames among the physical links according to the adjusted distribution algorithm.

19. The computer readable medium of claim **16**, wherein transmitting the marker message on comprises transmitting the marker message using an administrative queue associated with the physical link.

20. The computer readable medium of claim **16**, further operable when executed to perform the steps of:

receiving a remotely transmitted marker message at a port corresponding to one of the physical links;

monitoring queues corresponding to the port; and

transmitting a marker response on the physical link corresponding to the port in response to the monitoring of the queues corresponding to the port.

21. The computer readable medium of claim **20**, further operable when executed to transmit the marker response on the physical link corresponding to the port in response to all frames in the queues corresponding to the port having been processed.

22. The computer readable medium of claim **16**, wherein the disabling of distribution of additional received frames to the output queues and the purging of frames remaining in the output queues from the output queues result in dropping frames intended for the physical links such that dropped frames must be retransmitted.

23. A network element comprising

means for aggregating a plurality of physical links coupled between a first network element and a second network element as a link aggregation group;

means for distributing received frames among output queues, wherein each output queue corresponds to a physical link and the frames associate with a plurality of conversations such that all frames from any given one of the conversations map to a particular one of the output queues and the corresponding physical link;

means for determining to move at least one of the conversations from one physical link to another physical link;

means for disabling distribution of additional received frames to the output queues;

means for transmitting a marker message on each physical link in the link aggregation group;

means for purging frames remaining in the output queues from the output queues; and

means for receiving a marker response and, in response, enabling distribution of subsequently received frames among the physical links.

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UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 7,649,846 B2
APPLICATION NO. : 11/394892
DATED : January 19, 2010
INVENTOR(S) : Nakagawa et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

In the Claims

Column 15, Line 54, claim 9 after "frames among output queues," insert -- wherein each output queue corresponds to an aggregated port and the outbound frames associate with a plurality of conversations such that all frames from any given one --.

Column 16, Line 15, claim 12 after "The network element of claim" delete "**8**" and insert -- **9** --.

Column 16, Line 29, claim 14 after "The network element of claim" delete "**8**" and insert -- **9** --.

Column 16, after Line 57, claim 16 - "queues and the corresponding physical link;" insert -- determining to move at least one of the conversations from one physical link to another physical link; --.

Signed and Sealed this
Twenty-fifth Day of February, 2014

Michelle K. Lee

Michelle K. Lee
Deputy Director of the United States Patent and Trademark Office